Space Weather Technical Forecast

Issued on Tuesday, 11 July 2023 at 01:18 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/Minor Storm likely, chance of G2/Moderate Storm on 13 July with CME arrival. Chance of R1/R2 radio blackouts throughout. Slight chance of fluence becoming Active (1e8 integrated pfu).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate, with an M2.3 flare peaking at 10/0355 UTC, and a second M1.5 flare peaking at 10/2217 UTC, from the sunspot complex in the southwest, most likely from AR3366. There are currently eleven active regions on the visible disc. AR3361 in the northwest is the most magnetically complex region, with a small delta spot. AR3363 is the largest region in the southeast, but has lost its weak trailing spot so is now one large unipolar spot. AR3366, AR3368 and AR3369 are all close together in the southwest, with some magnetic interaction between these regions, probably increasing instability. AR3367 continues to evolve, but doesn't have any obvious significant complexity. A new unnumbered region on the southeast limb appears to be simple and unipolar. Many of the remaining regions appear to be small and simple at present.
A partial halo CME associated with the earlier M2 flare was seen travelling towards the southwest in coronagraph imager and an Earth directed component is considered probable as detailed below.

Solar Wind / Geomagnetic Activity: The solar wind as observed at L1 by ACE, was at slow-ambient levels throughout and solar winds varied between 330-370 km/s. The density was below average. Total magnetic field strength has been weak throughout, generally below 6 nT, whilst the north-south component also varied weakly. The phi angle has been steadfastly positive (away from the Sun). Geomagnetic activity has been at Quiet levels throughout (Kp 0-2).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, has been well below the S1/Minor Storm level, but is very slightly raised above the normal background as a result of the M-class flare. High energy electron flux (greater than 2MeV), as observed by GOES16, was at mostly moderate levels, with a peak of 933 pfu at 10/1810 UTC. The 24-hour integrated fluence was below the Active (1e8 integrated pfu) threshold on a steady trend. A fluence of 4.05e7 pfu was recorded at 11/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate solar activity is most likely through the guidance period, with a slight chance of an isolated X-class flare.

Solar Wind / Geomagnetic Activity: A partial halo CME associated with the M2 flare at 10/0355 UTC was seen travelling towards the southwest in coronagraph imagery. An Earth directed shock component is considered probable. At this stage, an arrival time of around 13/0600 UTC is most likely, but confidence is rather low. The solar wind is currently slow-ambient and is likely to remain that way until the CME arrival. As the CME effects continue, a HSS from CH23/- is likely to arrive during Day 3 (13 July). The combination of CME effects and HSS could lead to increased geomagnetic impacts.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

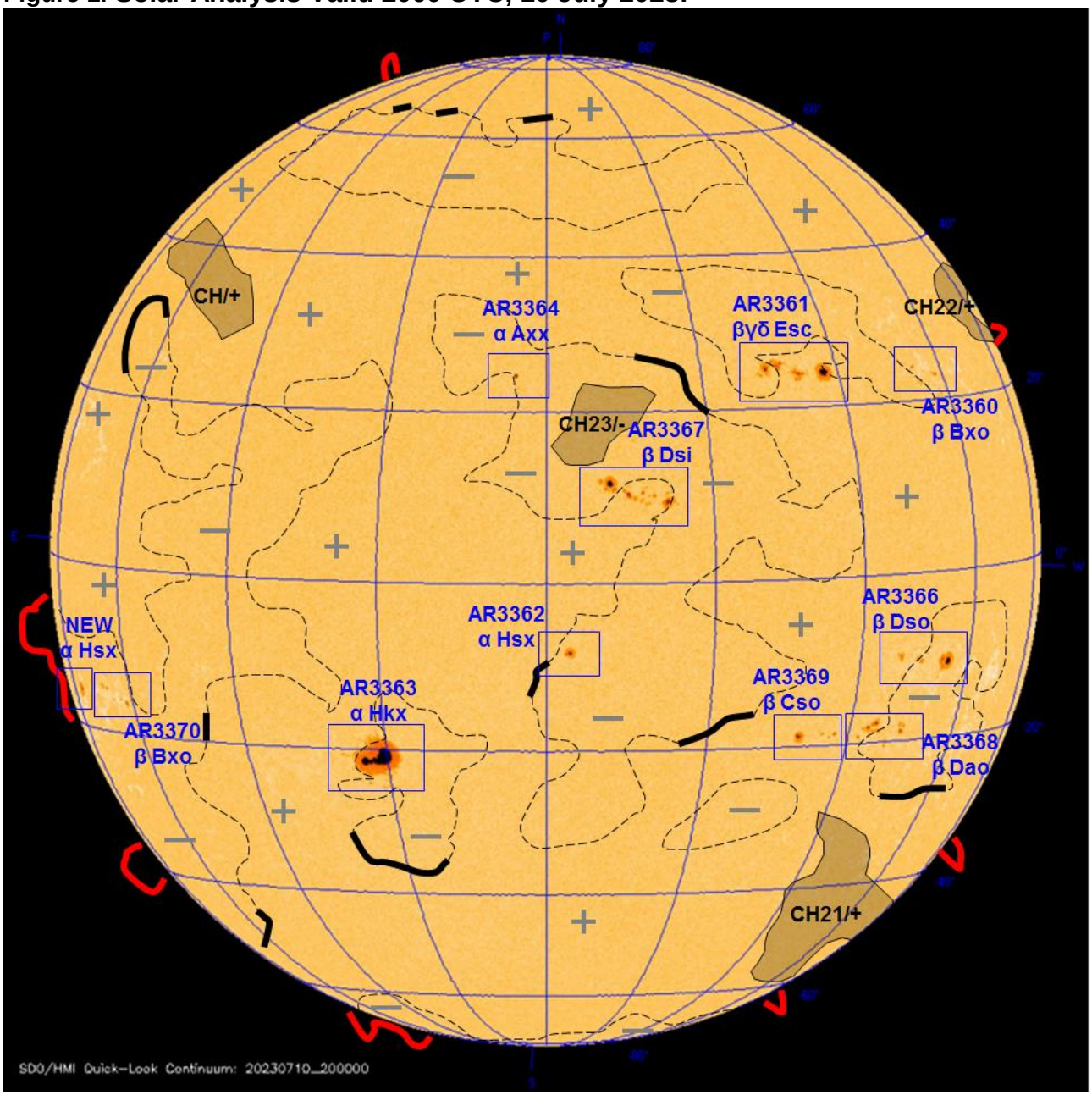
© Crown Copyright 2023. All Rights Reserved.

Met Office Space Weather Technical Forecast

Geomagnetic activity is forecast to be Quiet at first, becoming Active to G1/Minor Storm (Kp4-5) with a chance of G2/Moderate Storm intervals (Kp6) due to CME and HSS effects on Day 3 (13 July), then probably returning to Unsettled (Kp3) by Day 4 (14 July).

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux has a slight chance of reaching the S1/Minor Storm threshold through the period, should any larger flares occur. High energy electron flux (greater than 2MeV) is likely to reach moderate levels at first, with a sharp decline anticipated during Day 3 (13 July) as the anticipated CME arrives. Electron fluence has a slight chance of reaching Active (1e8 integrated pfu), before dropping during Days 3-4 with the CME and HSS arrivals.

Figure 1. Solar Analysis Valid 2000 UTC, 10 July 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

A partial halo CME associated with the M2 flare at 10/0355 UTC was seen travelling towards the southwest in coronagraph imagery. There was also a fainter asymmetric full halo from the shock. Although the bulk of the CME is expected to pass ahead of Earth, an Earth directed shock component is considered probable. At this stage, an arrival time of around 13/0600 UTC is most likely, but confidence is rather low.

The solar wind is slow-ambient and is likely to remain that way until the CME arrival. As the CME effects continue, a HSS from CH23/- is likely to arrive during Day 3 (13 July). On the previous rotation this feature resulted in solar winds reaching 600-700 km/s, and a maximum geomagnetic response of G2/Moderate storm. On this rotation the feature appears smaller and more fragmented in appearance, and this will probably lead to lower solar wind levels and associated impacts. However, the combination of CME effects and HSS could lead to increased geomagnetic impacts.

Geomagnetic activity is forecast to be Quiet (Kp0-2) at first, becoming Active to G1/Minor Storm (Kp4-5) with a small chance of G2/Moderate Storm intervals (Kp6) due to CME and HSS effects on Day 3 (13 July). Thereafter a decrease in activity is most probable with geomagnetic activity returning to Unsettled levels (Kp3) on Day 4 (14 July).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	30	20
Strong	G3	No	1	1	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

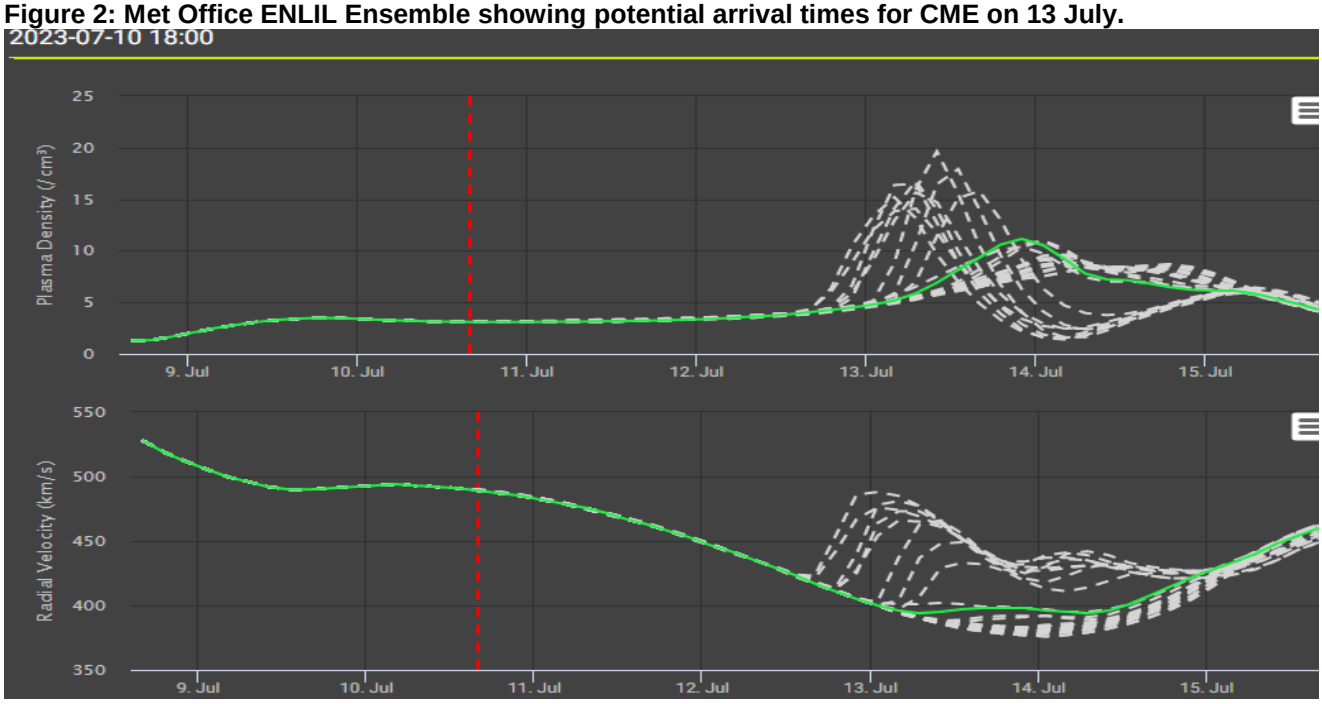
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
10/1107	Partial Halo	AR3366	SW	900 km/s	13/0600UTC	Limited shock expected. Rather low confidence for CME arrival

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 2: Met Office ENLIL Ensemble showing potential arrival times for CME on 13 July.



Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate, with an M2.3 flare peaking at 10/0355 UTC from the complex in the southwest, most likely from AR3366. A second low level and impulsive flare was observed peaking at 10/2217UTC from the same complex in the southwest, and probably the same Active Region.

There are currently ten active regions on the visible disc. AR3361 (Esi/Beta-Gamma-Delta) in the northwest is the most magnetically complex region, with a small delta spot. AR3363 (Hkx/Alpha) is the largest region in the southeast, but has lost its weak trailing spot so is now one large unipolar spot. AR3366 (Dao/Beta), AR3368 (Dao/Beta) and AR3369 (Cao/Beta) are all close together in the southwest, with some magnetic interaction between these regions, likely increasing instability. AR3367 (Dsi/Beta) continues to evolve, but doesn't have any obvious significant complexity at the moment. The new region on the southeast limb is not yet fully visible. The other regions appear to be small and simple at present. Low to moderate activity is likely, with a slight chance of an isolated X-class flare.

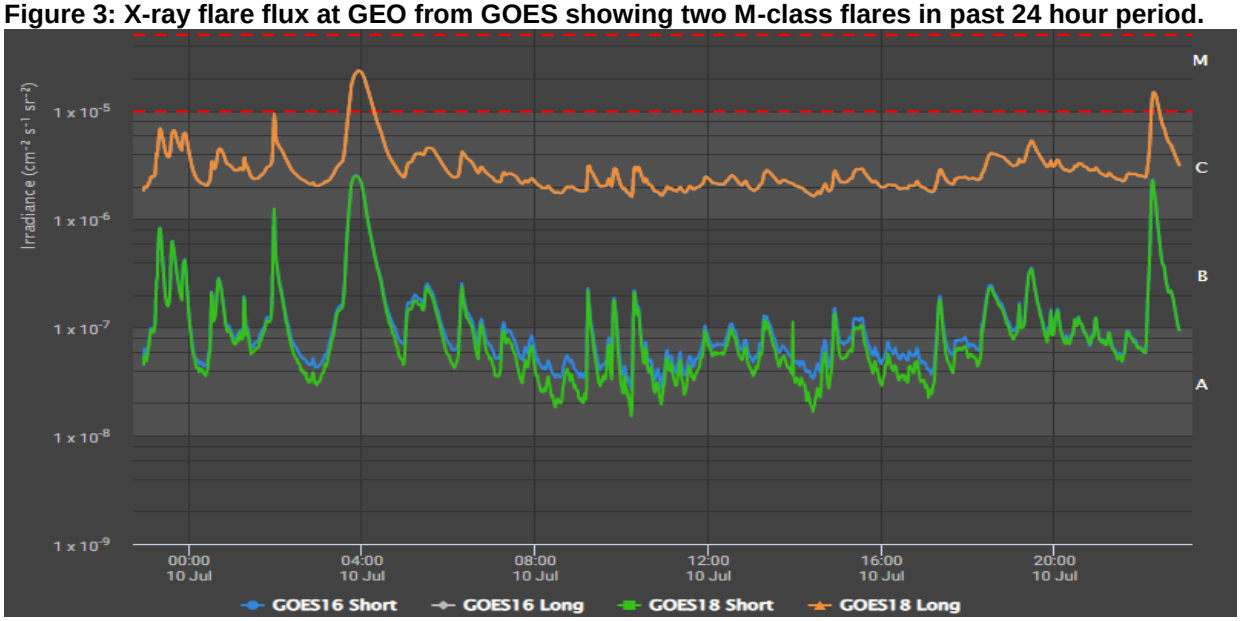
No major active region is forecast to depart the visible disc during the period and far side sounding data suggests that further regions may rotate onto the disc during the coming days. As these regions rotate across the eastern limb the flare probabilities have been raised a little for days 3 and 4.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	50	50	50	40
Very Active	R3 to R5 X Class	No	5	5	5	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 3: X-ray flare flux at GEO from GOES showing two M-class flares in past 24 hour period.

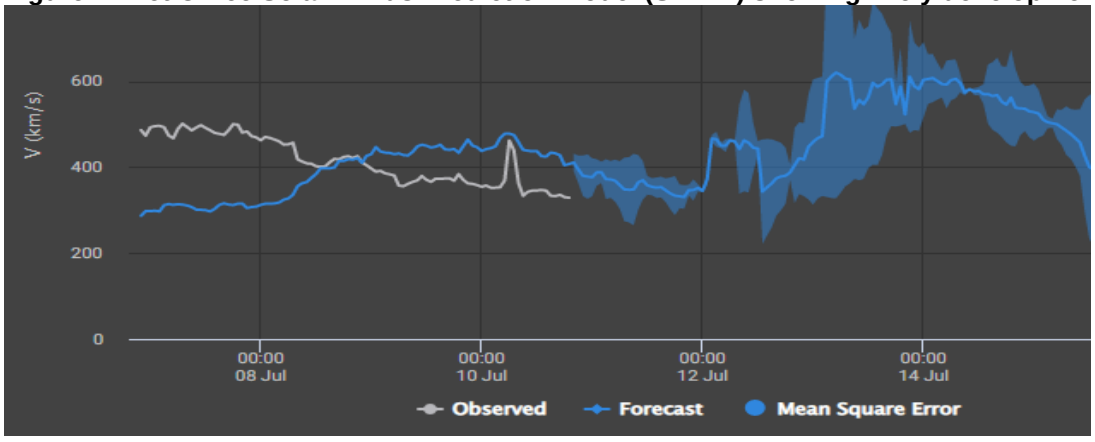


Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is currently near background levels, although very slightly raised in the wake of the M2 flare earlier today. There is a slight chance of S1/Minor storm levels being reached through this period, should any larger flares occur mainly from regions in the western hemisphere, and perhaps most likely from AR3366 which appears to be more favourable for this activity.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Met Office Solar Winds Prediction Model (SWPM) showing likely developments.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

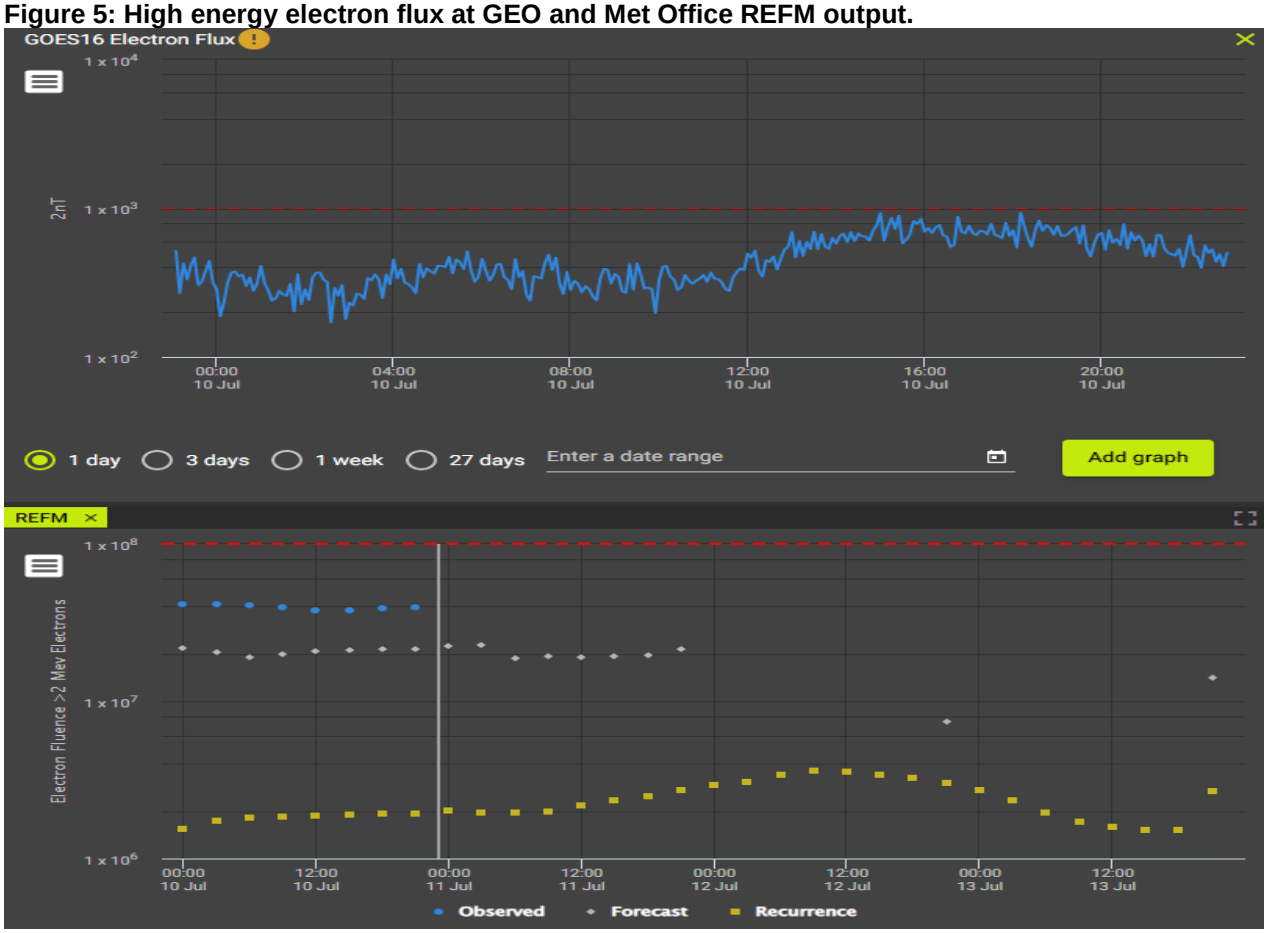
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) at GEO has been at moderate levels in recent days. The BAS radiation belt model suggests only a limited increase in electron flux has taken place below GEO, probably due to the recent HSS. Electron flux is now considered most likely to continue to reach moderate levels over the next couple of days. The expected arrival of a CME on Day 3 (13 July), soon followed or accompanied by a HSS is expected to give a sharp decrease in flux during the second half of the period.

Electron fluence continues to remain on a level trend below Active levels (1e8 integrated pfu). This is likely to remain similar, perhaps with a further slight rise possible through Days 1 and 2 (11-12 July), before a drop off on Days 3-4 as the CME and HSS arrive. MOSWOC REFM guidance is showing a steady trend below Active, which is considered to be giving sensible guidance although it won't be taking account of the likely CME arrival.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	10	20	10	5
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: High energy electron flux at GEO and Met Office REFM output.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.